CONCEPTUAL DESIGN METHODS for GAME SOUND

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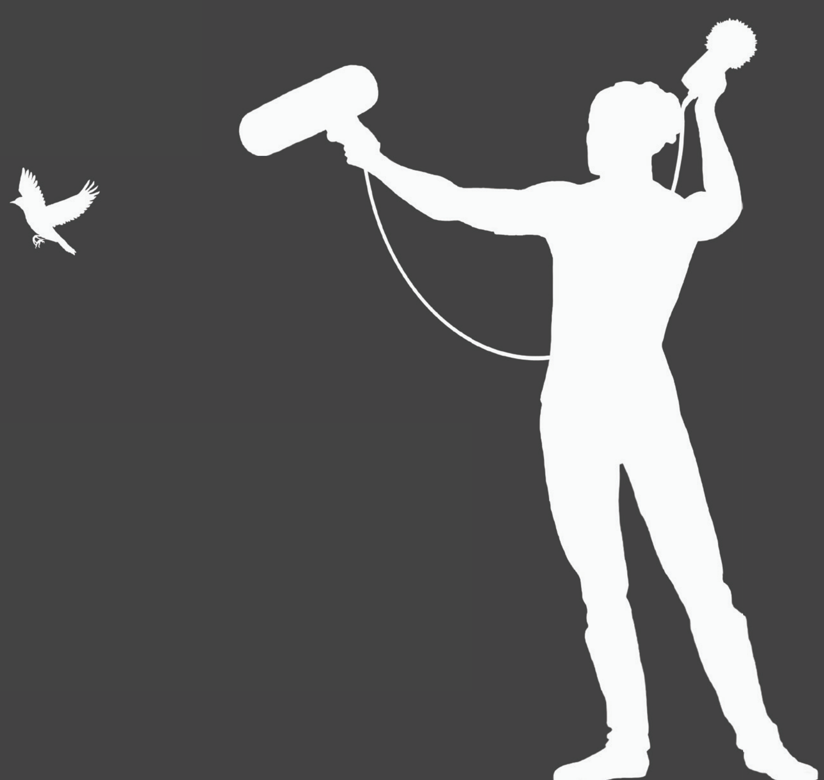

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CONCEPTUAL DESIGN METHODS FOR GAME SOUND

Master's Thesis

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Abstract

Existing game audio literature covers a plentitude of topics including practical areas such as production techniques, as well as theoretical areas such as terminology and taxonomy. However, these studies can still be considered somewhat limited in quantity and variety, since games are an academically young field, and game audio is even a smaller niche. In response to this scarcity, this study aims to provide a contribution to game audio studies, specifically aiming at exploring the sound effect design and production methods from the point of view of the sound designer. Most studies in similar vein either focus on directly hands on practices or solely theoretical aspects of game sound. Correspondingly, this thesis focuses on filling the gap between theory and practice by establishing a theoretical framework and numerous conceptual models that can be pragmatically applied in game sound design. The conclusions of the study are constructed and exemplified based on references to the existing literature and resources, numerous published video games, and various practical methods the author has applied in his own game projects. Ultimately, the thesis aims to provide a guideline that can help in creating a game soundtrack that is both narratively and ludologically cohesive, and that has contextual integrity regarding all the other game modalities.

Keywords Game, game sound, game audio, sound design, audio design. game sound design, game audio design, interactive sound, interactive audio, acoustic ecology.

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To Prof. Turgay Uzer
who was there
to give me the final push.

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INTRODUCTION

Video games are a constantly growing field of entertainment with the advancing technology, rapidly expanding industry and emerging popular culture that games propagate (ESA). This multifaceted growth creates grounds for developers to produce more elaborate and diverse content, and for scholars to expand and deepen their academic studies relating games.

As a multidisciplinary medium, video games comprise several sensory elements, sound being one of them. Audio design in the context of games hence refers to the process of producing, designing and implementing sound, music and voice for games. It incorporates a varying combination of artistic, technical and social skills to achieve desired design results (Bridgett, Game Audio 24). Most importantly, audio design for games differs in several ways from designing audio for traditional media such as film and music in terms of production practices due to its dynamic structure, even though most game audio production practices are borrowed and adapted from such fields. Moreover, the growing game industry gradually demands more and more competences from the audio designer. As a result, game audio design can be seen as a progressive discipline that requires dedicated study to be thoroughly understood.

Some of the scholarly examined topics in game audio include practical areas such as production, technology and supervision of game sound, as well as theory, terminology and functionality of sound in games. However, these studies can still be considered somewhat limited in quantity and variety compared to more established, mature art forms such as cinema and music. Therefore, game audio designers and scholars would benefit from further specialized studies to establish fruitful workflows, superior frameworks and comprehensive taxonomies.

This study aims to provide a contribution to the game audio studies, specifically by intending to link the gap between the theoretical and practical domains, which I believe exists in the current literature. The emphasis of the thesis is directed towards creating a soundtrack that is both narratively and ludologically cohesive, and that has contextual integrity regarding all the other game modalities (e.g. visuals, mechanics). Even though the focus is maintained on sound effects design, music and dialogue production is not completely omitted in order to keep a holistic perspective. I will investigate, discuss and present terminologies, taxonomies, workflows and methods, from the sound designer's perspective, towards devising conceptual yet pragmatic models. I will construct and exemplify my conclusions based on references to existing studies and resources, numerous published video games, and various practical methods I have applied in my own game projects. Ultimately, I aim to provide fundamental, at times in depth, guidelines of conceptual nature that can be practically utilized in game sound design, hence contributing to the existing game audio studies and improving my own understanding of game sound design.

The thesis is dissected into three main chapters, *Workflow*, *Soundscape*, and *Soundtrack*, plus the introduction and conclusion parts. The introduction presents the scope and the goal of the thesis, and explains what type of the methods and resources are used. The first chapter explores the essential game audio definitions, terminology and taxonomy, then investigates the sound production workflows in games. The second chapter presents an in depth analysis of game sound design and how it relates to the other modalities in games, finally proposing new models that can be applied in practice. The last chapter explores some concepts that are crucial for composing a holistic soundtrack by methodologically consolidating the individual sound design elements in regards to player participation. Finally, the conclusion summarizes the main ideas discussed throughout the thesis, and presents some closing thoughts and possible ideas for future studies. An appendix added at the end for the key terms frequently used throughout the text.

OF GODS, MANSIONS, AND TAILS

During my studies, I have been designing sound for several game projects, both inside and outside of the curriculum. These experiments provided the foundation and inspiration for this thesis, and some of them made their way here to directly support my arguments in form of practical examples. The games I will be occasionally mentioning between the lines are as follows:

- **Old Gods**

  A first-person adventure game for PC, set on a dark and mysterious world, in which the players guide Victoria to discover the secrets of her spiritual powers against the unearthly forces of the dead. Credits: Andrei Duván Rodriguez, Alexander Nikulin, Can Uzer, Jade Nash, Matteo Martinelli, Tamer Ekin.

- **Dark Room Mansion**

  A puzzle/adventure for mobile platform, targeted for pre-teenagers. Players enter a run-down mansion and solve the mystery of an old photography collection found inside by solving puzzles thematized as the traditional photography processing. Referred to as just *Dark Room. Credits: Andrei Duván Rodriguez, Can Uzer, Cristian Díaz, Niklas Kullström, Salla Vasenius, Ville Kuvaja.*

- **Dungeon Tails**

  A rogue-like dungeon crawler for mobile platform, in which the players control cute lizard-like heroes and dive into the depths of endless dungeons to seek adventure and glory. *Credits: Anni-Julia Tuomisto, Anton Valle, Can Uzer, Jonna Rantanen, Jukka Huiskonen, Sebastian Eriksson, Äki Martikainen.*

1. WORKFLOW: Producing the Soundtrack

Game development is an iterative, multidisciplinary and collaborative process, and game audio needs to fit into this complex picture as an embedded component, rather than being treated as an individual isolated process. In this chapter, I will investigate the definitions, tasks, typologies, stages, and components in game sound development to theorise and outline a practical workflow which is derived from the nonlinear, collaborative, agile and multifaceted properties of game development.

1.1. ESSENTIAL DEFINITIONS

To begin with, both *audio design* and *sound design* are interchangeably used to describe either the overall audio production or anything sound related but the music. According to the Oxford Dictionary of English, audio means "sound, especially when recorded, transmitted, or reproduced." In other words, audio refers to the reproduced analog or digital sound signal. In the context of video games, however, audio is always digital. To my understanding, due to the inclusive definition of the term, *audio design* for games comprises the design process of all types of sounds, which consist of sound effects, music, and speech. However, more often than not, composing music is treated as a separate discipline in the games industry, reserving audio design for the sound effects and voice production. In this sense, there seems to be no strict rules regarding the terminology in question.

Ambiguous enough, sound design may also be understood as equal to audio design. However, in order to clarify my focus and without further complicating the issue, I will use *sound design* in this text to imply a narrower area that is the individual practice of designing and producing *only* sound effects, hence excluding dialogue and music. Without being precisely strict, I generally use audio when referring to the entirety of sound effects, music, and speech.

1.1.1. Audio Asset Categories

An audio asset stands for each piece of music, sound and speech sample or system used in a game. To further clarify the types of sound in games, audio assets can be divided into certain categories.

According to two prominent sound scholars, Walter Murch and Michel Chion, sound can be semiotically perceived in different forms, which can be defined as speech, sound events, and music (Wilhelmsson, and Wallén 104). Liljedahl also recognises the use of the same three categories (31). Traditional film sound bears a similar approach by dividing each sound track as dialogue, music, and sound effect in post-production workflow. The same distinction pattern can also be observed in game audio. “In some ways, the game audio production process resembles that of the film audio process,” Collins explains (*Game Sound* 88).

Correspondingly, I divide the types of audio assets used in games into three main categories: sound effects (or just *sound*), dialogue, and music. Each one of these categories dictate dedicated study as individual disciplines, and the main focus of this thesis is *sound*. The categories in question are elaborated below.

- ❏ A ***Sound effect***, or just ***sound***, consists of individual sonic events and background noise that take place within the game. Any sort of non-verbal sounds that are propagated from the characters, objects, environment and virtual interfaces in the game belong to this group. Some examples include the hiss of the wind, the rumble of thunder, footsteps of an approaching enemy, or the bang of a shotgun.

- ❏ ***Speech***, or *dialogue,* self-explanatorily refers to the spoken words enacted by voice actors. The key element of speech is the use of language and conveyance of unambiguous information.

- ❏ ***Music*** is the most abstract yet emotionally powerful type of audio. The intelligent organization[1] of pitch, time, loudness and timbre of sound results in an aural form of expression which can be differentiated as music.

[1] This is not the say that other forms of audio is unorganized, but in music, the arrangement of sounds is unique so that it becomes a type of abstract language in itself.

1.1.2. Audio Creation Models

An essential distinction in game audio is based on how sound is provided to or generated within the game system. Farnell explains that the predominant contemporary method utilized in game audio is called *the data model* (i.e. data-driven model, sample-based model), in which the audio content is created in advance, prior to the implementation (318). Later, the recorded audio content (i.e audio samples) is integrated to the engine. The alternative method is called *procedural audio*, which treats “sound as process rather than data” (Nair). In procedural audio, sound is dynamically generated by the engine on run-time.

Farnell states that “early game consoles and personal computers had synthesizer chips that produced sound effects and music in real time, but once sample technology matured it quickly took over because of the perceived realism” (318). Sample-based audio still remains to be the predominant model today. However, more procedural elements are progressively introduced to the market, such as *SoundSeed Air*, a wind sound generator by Audiokinetic, hence promoting hybrid models. Presently, procedural audio can be seen as “a complementary technology and not a replacing technology” (Nair).

1.2. AUDIO PRODUCTION TASKS

The audio design process for games can be defined by three primary task groups: content creation, implementation and directing.

Audio content creation refers to the recording, generating, acquiring, composing, editing, manipulating, mixing and mastering of sound effects, dialogue, and music. In other words, content creation covers all the aspects of delivering final assets ready to be implemented. Recorded content, or audio assets, are the fundamental element of sample-based audio design. On the other hand, procedural systems that generate sonic content on run-time driven by the game data can also be considered as another form of asset (in this case, a piece of code).

Audio implementation, or *integration* is the process of integrating audio assets and/or systems into the game engine, establishing sonic behaviours, audio mixing, and revising the content according to the emergent demands. Kastbauer alternatively refers to implementation as *technical sound design*. A capable integration system is the key to realize and enhance the potential of the audio content. However, such system is undone without meaningful material. Likewise, an elaborate content is maimed without a competent system that is able to convey its potential. Thus, coherent design can only be reached through the successful marriage of system and content.

Audio directing is an element which can help realizing this aforementioned marriage, and it entails the undertaking of design, preparation and execution of the entire audio production, as well as handling the communication with other team members (when applicable). "The *audio director* is responsible for the entire soundtrack, from dialogue, ambience, sound effects and music. Not only this, but also working with the audio programmers on the desired technical requirements and direction of the audio and the wider design and art team in augmenting and leading feature design" (Bridgett, "The Role").

These three tasks ultimately form what can be called audio design, and can be assigned to separate individuals or groups, or shouldered by one person. Each task may require dedicated professional specialization (Game Audio Podcast), as well as varying degrees of artistic, technical and social skills, and all of them are equally important in achieving a successful audio design (Menhorn). In any case, there is a dynamic relationship between each task, mostly due to the iterative nature of game development. In the next section, I will discuss how these main task groups relate to each other, in what order, and in the context of game development.

1.3. AUDIO PRODUCTION STAGES

Filmmaking practices have a significant mark on game development, and production process for film is not an exception (Collins, *Game Audio* Ch. 5). In films, the entire production process is divided into three stages: Pre-production, production and post-production. In this format, each production task is executed sequentially during the stage to which it belongs. A similar pattern with some differences can be observed in games, but a major distinction is caused by the nonlinearity of game development. In games, ideas and assets are frequently tested; thus, they are subject to constant change. Minor or major alterations in design may occur at any time of the production due to the *iterative* nature game development. Resultingly, an audio designer may find herself going back and forth between varying tasks that presumably belong to the pre/post-production or production stages. Therefore, I reason that the traditional linear sequencing that is derived from filmmaking is inefficient by itself in reflecting a suitable workflow for game audio. Nevertheless, I agree that it can provide a solid starting point to work towards developing a game-specific scheme which I will exemplify below. To begin with, I will examine the confines of these production stages in question from the perspective of audio.

The Pre-production consists of defining design related and technological requirements, arranging schedules, listing required work load and assets, and establishing pipelines, frameworks and workflows (Brandon, Ch. 1). Basically, it is a stage in which the major decisions, plans and initial preparations are made. During this phase, mock-up sound samples may be created and implementation structures may begin to be built using placeholder sounds. Brandon also includes some actual production tasks in the pre-production stage, such as recording material and acquiring audio libraries. However, I claim that these subjects essentially belong to the production stage, even though it may be plausible to interchangeably treat them in both stages.

The production stage is the core phase of game audio development in which the assets are created, curated, edited and implemented, and the soundtrack is refined, mixed and optimized. In other words, the bulk of the sound design work is completed during this stage.

In *the post-production* stage, ideally, the game and the soundtrack should be already finalized. Therefore, the majority of the post-production involves the later stage of mixing (Collins, *Game Sound* 102) and optimization, as well as testing and revising.

Obviously, the meaning of these three stages in film production is not same in games. In film, the production refers to the shooting phase, whereas post-production is the period where sound design and editing takes place. Actually, digital animations and some CGI-heavy live action films seem to bear more similarities to game development since there is little to no actual shooting in these type of productions (Collins, *Game Audio* 105).

On the other hand, it is crucial to note that the games have a settled yet ever-evolving workflow of their own, derived by software development. Most games incorporate a certain variation of traditional methodologies such as agile product development, waterfall method or phased development (Bonin). However, common patterns and terminology can be observed, such as the prototype, alpha, beta, gold and soft launch stages. Figure 1 briefly explains these terms.

Prototype	The initial concept is developed and drafted. No actual production occurs yet.
Alpha	All the game features are implemented. Content is not final.
Beta	All the content is implemented. Content is final. Bugs remain.
Gold	Testing and bug cleaning is finished. The product is final.
Soft launch	The initial release of the game targeted on a non-primary game platform or geographical zone.

Figure 1. Common game development phases and milestones.

Regardless of which development methodology and milestones are used, the essential pattern seems to be similar in both games and film. Combining both worlds in a compact form, I conclude that the main stages of game development can be defined as *initiation*, *execution* and *completion*, and suggest that this taxonomy can be utilized in audio production for both large and small scale games.

In the *initiation* stage, the idea is developed, first drafts are sketched and a production plan is established. During the *execution*, the actual production happens; all the features and content is produced and implemented. The *completion* is the stage in which the final testing, debugging, revising, finalization, release and post-release maintenance processes take place. Figure 2 clarifies the associations between the terminologies discussed above.

Another key point worth mentioning in regards to the production stages is the dependencies between team members. Bridgett stresses that "during production, it is often the case for each component of game audio to be either dependent on some other area of work [e.g. animations] to be completed, or some other area of the game is dependent on audio finishing a particular piece of work [e.g. dialogue]," and adds, "this is also a neglected area of collaboration with the rest of the planning team (…)" (*Game audio* 49). Therefore, it is essential to consider these type of dependencies and their reflections on the audio production stages, and to plan the schedules accordingly.

Game production stages	**Game development phases**	**Film production stages**
Initiation	Conceptualization, prototype.	Pre-production.
Execution	Pre-alpha, alpha, beta.	Production, post-production.
Completion	Gold, soft-launch, release, post-release.	Premiere, distribution.

Figure 2. Game production stages in regards to game development and film production pipelines.

1.4. SOUND PRODUCTION COMPONENTS

In the previous section, I attempted to outline and explain the game production stages from an audio perspective. Now, I will examine the individual components of sound production, and how they fit into the game production workflow. Figure 3 lists the essential components of game sound production and display their positions in regards to the broader workflow components including production stages, production tasks and design mindsets, the latter being a new concept that I will present in the next section.

Stage↓ Task⟶	**Directing**	**Creation**	**Implementation**
Initiation	Styling [Authoring] Scheduling [Constructing]	Asset Cataloging [Authoring]	Engine integration [Constructing]
Execution	Supervising [Authoring]	Recording [Crafting] Editing [Crafting] Synthesis [Crafting] Library curation [Authoring]	Session arranging [Constructing] Soundscape refining [Crafting] Mixing [Crafting] Optimizing [Constructing]
Completion	Revising [Authoring]		

Figure 3. Sound production components.[2]

- ***Styling*** involves defining of the artistic vision, benchmarking and establishing the audio identity of the game. Frequent design meetings may occur, mock-up sound assets and systems may be required for demonstration purposes. Ideally, styling changes should not occur after the initiation stage.

- ***Scheduling*** phase connects the audio production dates with the entire game production timetable; it consists of assembling a project calendar, marking deadlines and milestones, and distributing the tasks on a timeline. When planning an audio production schedule, communicating with the other team members is essential, particularly in regards to clarifying expectancies and dependencies.

- ***Asset cataloging*** involves listing and categorizing required assets, and outlining the production demands and methods for each asset. Finalizing the asset list may not be

[2] The comments in superscript form are called *the sound design mindsets* which will be explained in the next section.

possible during the initiation stage; alterations in game design and assets during the execution stage may cause further changes to the list.

- ***Engine integration*** refers to deciding what sort of implementation systems will be used, establishing and/or integrating the audio engine with the game engine, providing collaborators network access (version control systems and/or physical networks) to the project repository, and ensuring that the audio engine is ready for the audio integrators' use.

- ***Supervising*** is the element which orchestrates and cements all the other audio production components. Authoring a coherent whole from individual processes of audio production is ensured via a holistic understanding and execution of supervision, whether or not the audio team consists of a single person or multiple entities. The boundaries of supervision also stretches out to the initiation and completion stages.

- ***Recording*** is one of the core components of sound production during which the materialization of sound assets occur. Recording may happen in a dedicated studio or out in the field, using location recording and foley techniques, vocal effects or instrumental methods (i.e. using musical instruments, voice, synthesizing and sampling). It is crucial to plan recording sessions so that the allocated time (and location) for recording is most efficiently used.

- ***Editing*** is the phase where recorded material is evaluated, trimmed and transformed into assets ready to be implemented. More than one audio clips can be mixed together to achieve the desired result, or multiple samples can be delivered as separate layers to be blended as one sound event in the engine. Implementing and testing edited assets in the game may result in further iterations of re-editing, or even re-recording; so, it is beneficial to implement the edited assets as early as possible during the execution stage.

- ***Synthesis*** (not to be confused with *recording* synthesized sounds) refers to the process of building and/or operating sound generators that are integrated into the engine in order to establish procedural sound generation within the game. This is a component that differentiates from the rest of the sample-based production routines by allowing the game engine to generate its own sounds on run-time, sounds that are innately connected with the game parametres.

- ❏ ***Library curating*** is yet another approach of acquiring sounds, which involves browsing external sound libraries and selecting appropriate sound samples to be implemented. Further editing of the selected sound samples may be required.

- ❏ ***Session arranging*** involves the groundwork for the more creative components of the implementation process to be executed fluently: establishing the signal chain, assigning audio busses, importing assets to the engine, setting up folder and file hierarchies, linking game and audio events together, and ensuring that the correct naming conventions are enforced and the broken links are troubleshot.

- ❏ ***Soundscape refining*** describes the process of architecting the sonic environment of the game and the sonic activities that take place in it within the engine. Arguably being the most creative aspect of the audio implementation process, soundscape refining consists of constructing an aural space that suits to the thematic design of the game and that is capable of reacting to the game events in a dynamic manner. In a way, soundscape refining resembles an aural set dressing process in which the game is populated with all the required sounds, and the dynamic behaviours of the soundscape, both coarse and fine, are adjusted.

- ❏ ***Mixing*** is both the aesthetically and technically necessary treatment process of an arranged and refined game soundtrack. Traditional audio mixing practices, such as adjusting volume levels and balancing the panorama, equalizing, compressing, limiting, ducking, and applying other effect processors such as reverb, are utilized in a way that is appropriate for the nonlinear environment of the game. Mixing will most probably happen in multiple stages during both the execution and completion stages.

- ❏ ***Optimizing*** ensures that the audio package stays within the limits of the given processing and memory budgets of the game. Not only that, other technical necessities such as voice prioritization are managed, and potential audio glitches are fixed through continuous testing. Last but not least, varying batch processes such as applying different file conversion settings (e.g. file compression, sample rate, bit depth and file format conversion) and package limitations (e.g. reducing memory and/or processor footprint, voice limitation) may be enforced in regards to various platform-specific requirements. The optimization will most possibly span the completion stage.

- ***Revising*** is an umbrella phase which comprises the finalization of the audio production: testing the game, quality assurance, replacing assets and completing the final mix and optimization passes. The final revision of the game soundtrack helps ensuring that the desired audio identity is achieved.

The components described above are the essential building blocks that make a finished game soundtrack. The terminology is not absolute, and it may differ to a certain extent for any given game project since some of these terms are not firmly established in game development, and each game requires a unique production approach. There may also be more components to be added to create a more detailed scheme. Nevertheless, the main point of defining these components here is to outline the essentials of the game sound design process in order to provide a starting point for creating a development plan, to help understanding the nonlinearity and synergy between each component, and the social engagement between the various parties involved in the development.

1.4.1. Convoluted Components

Looking at Figure 3, the game audio development resembles a linear process comprised of individual components. However, each of these components relate to each other in a complex fashion, and during the development, an audio designer may keep jumping back and forth between each phase. Illustrating some design scenarios may help clarify the nature of these complexities:

1. During the *soundscape refining* phase, the sound integrator figures that it would add diversity to the soundscape if each three layers of a car engine sound (engine bay, induction and exhaustion) can be individually controlled. The existing asset is a stereo mix of all the three layers. Thus, the integrator asks her sound designer colleague to render each layer of the engine sound as individual mono tracks (*editing*). After receiving the re-edited assets, she re-imports them to the game (*session arranging*) and readjusts the engine sound behaviour accordingly (*soundscape refining*).

2. During the *revising* period, the audio director receives feedback about the user interface response regarding the *upgrade building* action, noting that the existing sound is not rewarding enough. She decides that the existing asset should be replaced to address this issue, but there are not enough resources to record a new sound at this later stage of development. So, she instructs her senior sound designer to browse new sound libraries and find a matching asset (*library curating*).

3. During the *execution* stage, the game designers decide to add a new geographical area to the game: a volcanic landscape of ash covered hills. In order to discuss the unique sonic identity of this new area, the solo sound designer of the game is asked to postpone her field recording session (*recording*) and meet with the team leads to have a design discussion (*styling*).

The scenarios mentioned above demonstrate three important points in game sound production. First of all, most components of sound production are connected, and these components affect and depend on each other in various ways. In other words, the components are bound together with fluid connection, and the ideal workflow should accommodate to this fluidity. Second, the production happens in an iterative manner, meaning that the same procedures happen in cycles until the desired result is achieved. And the third point is that the sound design process involves "several layers of collaborative and communicative endeavour;" hence, it should be considered as a partially social discipline rather than isolated (Bridgett, *Game Audio* 31). Therefore, the game sound production is a cross-discipline, synergic, nonlinear and social process.

1.4.2. Sound Design Mindsets

So far, two dimensions are utilized to map the sound production components to the game development process: audio production tasks and audio production stages. However, a third dimension may help contribute understanding the sound production components as a part of a holistic discipline, considering the collaborative and nonlinear aspects mentioned above. I call this conceptual dimension *the sound design mindsets*, since each component in game sound production tend to rely on a certain set of skills and way of thinking to be accomplished. These mindsets consist of *authoring*, *crafting* and *constructing*. Figure 4 shows which component is associated with which mindset.

Sound Design Mindsets	***Sound Production Components***		
Authoring	*Directing*	*Creation*	*Implementation*
	Styling Supervising Revising	Asset cataloging Library curating	
Crafting		Recording Editing Synthesizing	Soundscape refining Mixing
Constructing	Scheduling		Engine integration Session arranging Optimizing

Figure 4. Sound design mindsets.

Constructing involves mechanical tasks and technical structuring. Handling compatibility issues, installing and organizing technological systems such as hardware, software and middleware, and optimizing technicalities are the obvious examples, but organizational tasks such as planning, budgeting and scheduling may also be considered as the parts of constructing.

If constructing resides at the technical end of the spectrum, ***crafting*** lies on the other. The most artistic, hands-on tasks are related to this mindset: capturing and shaping sounds, tweaking implementation parametres, listening how the game soundscape sounds and altering it accordingly, and the rest of the countless creative practices involved in sound design.

Authoring refers to the broader aspects of sound design which guide, orchestrate, oversee and glue the components that are related to the other mindsets, and conduct a coherent whole out of the individual elements. Occupying the middle ground between technique and art, authoring involves the design, supervision and curation of the sound production. Most *directing* related tasks exist in this domain.

The sound design process shifts between these mindsets throughout the production as iterations occur between each task and component. Obviously, some components will occasionally overlap, and some are related to multiple mindsets to varying degrees. The same type of fluidity that binds each sound production component also applies for the mindsets. Nevertheless, these mindsets can provide an alternative way of viewing the workflow and adjusting one's perspective to the nonlinear essence of the game sound production. For instance, a sound designer may feel like tackling with constructing related tasks in a given period where she is lacking sufficient inspiration to handle the elaborate crafting errands. Likewise, it might be a good time to take step back from dealing with microscopic technical details, to see the bigger picture and to author the coarse direction of the design. Figure 4 shows the sound production components organized based on the design mindsets primarily related to each component.[3]

1.5. SOUND EFFECTS TYPES

In Chapter 1.1.1, I concluded that the sound effects are a type of audio asset. However, different sound effects may require different production approaches. Thus, it can be beneficial to further define subcategories from a production point of view. The existing classifications seem to be mostly adapted from film sound, and a game specific approach to the topic may provide benefits for the game sound design workflow due to the various reasons I will present below.

According to *The Use of Sound Effects* by BBC, sound effects "cover everything which comes out of a loud-speaker, except what is usually classed as *music* or *speech*" (194). The article further distinguishes sounds depending on their "quality and function," and lists primary genres such as realistic, symbolic, conventionalised and impressionist. These definitions are evidently structured particularly for broadcast programmes, hence not particularly fruitful in the context of games. The modern western cinema uses a more straightforward approach and sorts the sound effects according to the way they are produced:

- ***Hard effects*** represents solid, mechanic sounds such as tools, machinery, guns and vehicles. They are generally difficult to replicate in a studio environment. Most sound designers rely on sound libraries to acquire hard effects, but depending on the project budget, they can be recorded in the field or studio as well.

- ***Foley*** refers to organic movement sounds (eg. footsteps, cloth rustles, eating, daily objects that characters interact with) which are typically synced with the image. The

[3] Please note that the Figure 4 does not address all the possible overlaps between the components and the mindsets. In other words, some components may extend over multiple mindsets.

most significant element of foley is the involvement of performance (Ament). In most cases, foley is recorded in a dedicated studio.

- ❏ ***Ambiences*** (atmos, atmosphere, background) are territorial sounds that indicate and enhance the setting, and not necessarily providing an entirely faithful representation of the image in every case. Naturalistic or urban ambiences are recorded in the field, both outdoors and indoors.

- ❏ ***Design effects*** refers to sounds that are produced to depict imagined, invented or metaphorical events. Most sci-fi or fantasy effects that need to be designed artificially, or musical sound layers and drone tones that help to set the emotional mood, are in this group. Design effects are generally produced as a mixture of sound synthesis, library browsing, studio and field recording, and heavy sound manipulation. Some sources (e.g. Viers 4) define another group, *production elements*, to include electronic sounds, such as static noises, buzzes or whooshes, as well as all kinds of musical effects, but I prefer to consolidate these elements in design effects, due to the similar nature of the two groups.

Common film sound categorization is practical and can be beneficial in game audio design. However, it also has several shortcomings and becomes rather inaccurate when applied to the interactive and nonlinear worlds of games, as I will discuss below.

First of all, synchronization of sound and image works uniquely in games. In games, a certain sound effect (and its variations) can be used for more than one visual event, whereas in movies, all the events and sounds happen only once; thus, rendering any existing synchronization absolute. This distinction is especially significant in terms of how foley work in games. To illustrate, in *Shadowrun Returns* (hereafter just *Shadowrun*), most characters seem to have the same set of footstep sounds, even though the character graphics and animations are not identical. Consequently, synchronization of sound and image is relative. Absolute synchronization is one of the key elements in performing foley for film, whereas in games, the same concept is relative due to player involvement and event repetition.[4] Therefore, game foley mostly relies on sample variations rather than precise representation of the sound's visual

[4] Synchronization in game sound will be addressed in detail in Chapter 2.3.

source, and most of the time, the sound follows the player action more than the visuals. Most hard effects and some design effects also display the same characteristic.

Second issue arises from the imaginary nature of games. “Gameworlds are different constructs compared to traditional fictional worlds,” explains Kristine Jørgensen. (87). “Such worlds are created around a different logic than *fictional storyworlds* and, as long as all elements are explained as being parts of the game system, they do not need to be a credible part of a hypothetical world.” This means that the sounds used to help building the gameworld are not of the same nature with those used for films. In *Fez*, when the main character jumps, we except the noisy beep sound he makes as an innate physicality of the gameworld, instead of anticipating a realistic sound response from that action. O’Keeffe remarks that “sound in itself provides a sense of reality whether or not the sound is based on reality” (56). Droumeva addresses the same point by introducing a listening mode called *nostalgic listening*, referring to a “culturally-critical type of listening” (145) that has emerged from the historically iconic game audio examples. Our expectancy from a gameworld is therefore different from what we would expect from a storyworld.

Of course, one can argue that if the storyworld of a film provides the audience with an 8-bit fiction similar to *Fez*, the audience’s expectation of authenticity would be the same. This is indeed true, unless we count into account that the games are systems that convey information through interfaces (Järvinen 49), apart from being a narrative medium. That being so, games involve a particular sound effect group which can be called *interface sounds,* the most obvious examples of it being the menu buttons and notifications. The problem surfaces when it comes to making a clear distinction between the interface and diegetic sounds[5] (i.e. the sounds that happen within the gameworld). Briefly, the fact that some interface sounds are integrated into the gameworld in varying levels blurs the line between what sound is a narrative or an informational element. In other words, some sounds are convoluted into the gameworld in a way that makes it difficult to distinct if they are dedicated interface responses or a native part of the narrative sphere. Consequently, the player’s expectation of authenticity from a game soundscape is based on a convoluted mixture of narrative and informational sound elements, unlike the traditional film sound which is free of any interactive interface. In this case,

[5] I will discuss the notion of diegesis and the related issue in great detail in Chapter 3.1.

cinema-based sound effect categories become functionally inefficient to be used in game audio production.

To summarize, combined with the concepts of relative synchronization, imaginary gameworlds and dynamic game interfaces, the distinction between hard effects, foley, design effects and ambiences turns vague in game audio. Can a foley sound without synchronization be called foley anymore? What is natural or unnatural in the gameworld, in terms of hard and designed effects? How should interface sounds be categorized? Where is the exact line between an otherworldly ambient soundscape and a music track? Finally, how answering these questions can possibly improve the sound production workflow?

1.5.1. Concrete, Abstract and Ambient Sounds

In order to tackle with the questions above, I dissect the sounds based on the way they are produced in games: Concrete, abstract, and ambient.[6]

- ***Concrete sounds*** refer to the sounds that are analogous to real world events. A footstep, a door slamming, a glass dropping on the floor… Sounds that anyone can recognize as real, that can be replicated in studio or field by using physical objects. Concrete sounds involve hard effects and foley, but do not necessarily signify a sharp conceptual distinction between them due to the relative synchronization. It is relevant from the sound designer's perspective to define a certain sound as concrete, because this distinction would determine whether or not it is possible to actually capture the sound or authentically replicate it, as well as where and how it is possible to record or acquire it.

- ***Abstract sounds*** are a slightly different interpretation of design sound effects. Games often incorporate imaginary themes which require corresponding sounds to be designed. Symbolic movement sounds like the jump sound in *Fez*, magical effects such as a fireball spell in *The Elder Scrolls V: Skyrim*, or sci-fi elements such as firing the Portal Gun in *Portal* are all abstract sounds. There is no direct correlative sound sources to these specific sounds in real life. They are derived from the imagination

[6] The taxonomies based on the game related functionalities of sounds will be presented in the next chapter.

depending on a particular design intention. Thus, the abstract sounds are metaphorical, or symbolic. The design of abstract sounds often involves heavy processing of recorded concrete sounds and synthesized audio. Additionally, non-realistic interface sounds can also be considered in the abstract group. Switching between menu items in *Tomb Raider* is accompanied by an abstract *whoosh* that serves as an interface response.

- ***Ambient sounds*** includes territorial sounds, as well as emotional mood layers up to a certain extent.[7] Birds chirping, wind blowing, the distant hum of traffic or loud ventilation buzz are some concrete examples of ambient sounds. An example is the naturalistic representation of the tree-covered hills in *Superbrothers: Sword & Sworcery EP* (hereafter just *Sword & Sworcery*). However, ambience can also contain abstract elements, mostly in form of a mixture between an arrangement of artificial sounds and musical components. In *Limbo*, the naturalistic forest ambience shifts into a low frequency drone, which resembles a magnetic buzz, when the hostile giant spider approaches. In this example, two things are worth mentioning: First, an abstract sound design is utilized as ambience (and perceived as the gameworld's intrinsic reality), with the musical purpose of intentionally changing the emotional mood; second, the ambience serves as an interface for conveying the information that a threat is near to the player.

Understanding which sound events belong to which type of sound can help a sound designer to designate asset creation workload, methods and scheduling during the initiation stage of a game. In most real-life scenarios, the majority of concrete sounds will be recorded and edited in the studio, while the rest will be acquired externally or captured in the field. Most abstract sounds will be created digitally or electronically in the studio, and maybe mixed with some recorded concrete sounds to achieve final results. Ambiences will predominantly rely on multitrack field recordings, individual environmental elements, or musical patterns, depending on the game's theme. It is important to note that some sound effects may incorporate multiple

[7] Some abstract sound effects which display somewhat musical characteristics can be used as metaphorical ambiences to help set the emotional background. Although, there is a certain point at which these types of sounds should be simply called *music,* at the extent where the sounds are clearly organized and arranged in a compositional fashion. Liljedahl comments that "the border between the two [music and ambience] is more and more often blurred by film and game sound designers" (38).

layers of sounds from each group, and game genres determine the predominant sound types that will be required. Nevertheless, the taxonomy presented above can help planning the design process in most cases.

One exceptional category worth mentioning is the vocal effects. Sometimes vocal performance can be used as an instrumental tool to create sounds effects. In *Botanicula*, all the sounds in the game except music and some musical gameplay elements are produced using vocal performance, in a way similar to *a cappella* singing in music. Similarly, I heavily used vocal effects in *Dungeon Tails*, to give a cartoonized personality to the characters and objects that fill the gameworld. However, I consider this sort of vocal performance as a type of instrument rather than an individual sound effect category. The methods of creating sound effects vary depending on the style, requirements and availabilities of a game project, and vocals are one of the many ways of generating sound.

2. SOUNDSCAPE: The Multimodal Ecology of Game Sound

In the previous chapter, I investigated the production related issues in game sound, and attempted to outline an ideal workflow and various taxonomies. In this chapter, I will explore the functions of sound in games as a narrative and informative tool that is capable of expressing ideas and emotions, and conveying useful information. After discussing relevant literature on the topic and accordingly constructing a framework, I will present a practical model to be utilized in game sound design. The purpose of such effort is to understand and exploit the functions, characteristics and contexture of individual sound components in relation to the overall design, a relationship I term *the multimodal ecology* of sound. In order to clarify what a multimodal ecology of sound means, first the acoustic ecology of game sound must be defined.

If the ecology is defined as the relationship between the environment and the living beings that interact with it, then *the acoustic ecology* is the relationship between the soundscape and the listener (Grimshaw, Ch. 1). A soundscape, which is the combination of all sounds sources and sound events in a given environment, can be understood as analogous to a landscape (Murray Schafer). In this sense, the acoustic ecology of game sound is the outcome of the relationship between the game soundscape (sonic environment) and the player (the source of interaction). In other words, the player's interaction with the inherently static soundscape creates a dynamic aural setting, which can be defined as the acoustic ecology.

I suggest that an analogy can be made between the acoustic ecology of game sound and the micro-dynamics within the soundscape itself. A game soundscape consists of numerous elements, rather than just sound sources and events: the connections between sound and image, sound and haptics, sound and player action, and sound and game engine. Not only that, there are varying layers of narrative actors that are involved in a game soundscape, which will be inspected below. Accordingly, if the sound sources are considered as the elements that form the environment of a soundscape, then the dynamic relationship between the sonic actors and all the other game modalities acts as the active participants of the same system, creating a sub-ecology. I believe that this multimodal ecology of game soundscape ultimately manifests a global sonic narrative through the acoustic ecology of the game, which indirectly produces a ludological impact on the game play itself. In this chapter, I will discuss the elements that build this multimodal ecology, and eventually build a framework that can be applied to the game sound design.

Some notable literature that can provide the theoretical background for such line of thought include Chion's audiovisual scene theory (Ch. 1.4) and Murch's conceptual model ("Dense") in film sound context; IEZA-framework suggested by Huiberts and van Tol for game audio; a combined model contributed by Wilhelmsson and Wallén; Jørgensen's spatial integration model; and Collin's concept of dynamic activity (*Game sound* 125).

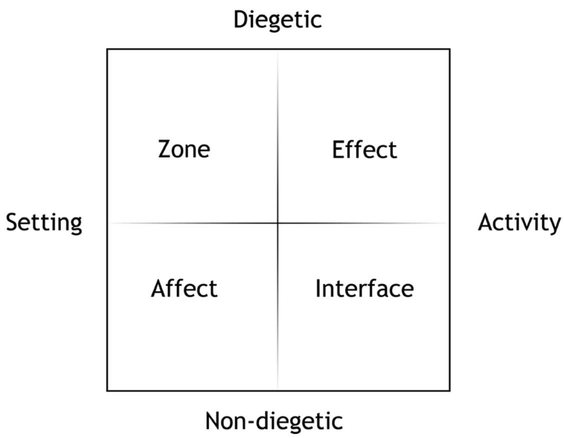

Figure 5. IEZA framework (Huiberts and van Tol).

One of the existing models, "the IEZA framework[,] defines the structure of game audio as consisting of two dimensions". The first dimension is derived from the *origin* of audio, which is divided into *diegetic* and *nondiegetic* domains. Diegetic sounds take place in the narrative world; they are originated from the characters and the environment (e.g. dialogue, footsteps, ambience). The nondiegetic sounds, on the other hand, are disconnected from the story world itself, yet they support the narrative externally (e.g. music, narration). The second dimension is based on the *expression* of game audio, whether the sound is based on the *setting* of the game (environmental and ornamental sounds) or the *activity* in the game (sounds that are resulted by player interactivity). Four groups of sound in total occupy the space between the origin and the expression dimensions: Zone, Affect, Effect and Interface. Figure 6 briefly explains each group.

Zone	Noninteractive and diegetic ambience or music (forest ambiance, *source music*).
Affect	Noninteractive and nondiegetic ambience or music (combat music, ambient drones).
Effect	Interactive and diegetic sounds (footsteps, gunshots, dialogue, passing cars).
Interface	Interactive and nondiegetic interface sounds (menu buttons, mouse clicks, notifications).

Figure 6. Sound groups in IEZA-framework (Huiberts and van Tol).

Wilhelmsson and Wallén extended the IEZA-framework by introducing the layers of cognitive, spectral and dynamic load, partly based on Murch's conceptual model ("Dense"). To clarify, they introduced more parameters which help organizing sounds in a way that allows observing and limiting excessive sonic congestion (or *logjam*, as Murch calls ("Dense")) in the soundtrack. In other words, their *combined model* allows to spot the dominant frequency domain, loudness rating and cognitive density of each sound.[8]

Jørgensen further contributed to the progress by arguing that the notion of diegesis falls inaccurate in game audio and urging to "use an approach that allows us to describe it [sound] in terms of an interface" (93) instead. Her work poses an alternative approach to the dimension of origin (diegetic-nondiegetic) and interface sounds of the IEZA framework.[9]

From the perspective of designing sonic narratives in a functional way, the line of thought briefly explored above provides a solid starting point, especially regarding the concepts of diegesis, involvement of player activity, meaning in sound, and sound as an interface. Below, I will individually delve into each of these topics and more while further clarifying the existing models.

[8] Wilhelmsson and Wallén's combined model and Murch's cognitive model will be discussed in greater detail in Chapter 2.2.

[9] Jørgensen's spatial integration model will be discussed in Chapter 2.1.

1.1. DIEGESIS AND SONIC INTERFACE

Diegesis is a concept that is adapted to games from theater, cinema and literature. Simply, sounds that emerge from and belong to the narrative world are called diegetic, whereas sounds that dwell outside of the narrative world are nondiegetic. For example, the speech of a character who is talking to another character in a film would be diegetic, whereas the music that has no apparent source on the screen would be nondiegetic. In *Tomb Raider*, the gunfire of Lara Croft's pistols is diegetic, but the abstract menu button sounds are not. Such distinction can provide a useful awareness, since it can be utilized in designing the functionality and thematization of sounds.

Metaphorical interface	External music. Metaphorically connected to the game narrative.
Overlay interface	Static user interfaces. Menu sounds, status sounds, external interface responses.
Integrated interface	Interface sounds that are narratively integrated to the gameworld. Collecting a coin.
Emphasized interface	Sounds responses that are adapted to the situations posed by the player. NPC[10] dialogue.
Iconic interface	Sounds that are completely integrated to the game narrative. Footsteps, player grunts.

Figure 7. Spatial integration stages (Jørgensen).

That being said, diegesis does not appear to be unproblematic. Jørgensen reveals the shortcomings of such distinction in games and reasons that "the traditional distinction between diegetic and nondiegetic is not based on participatory use [of sound] and does not allow us to describe game sound in this way" (93). Essentially, the argument emerges from the fact that the notion of diegesis is borrowed from linear media, which makes it unfitting for the interactive environment of games. Accordingly, she treats sound as an interface and identifies multiple integrational degrees based on how deeply these sonic interfaces are blended into the gameworld, instead of relying on the traditional concept of diegesis. Figure 7 shows the five levels of interface that Jørgensen define as *spatial integration*. Additionally, Droumeva argues that "it [diegesis] fails to recognize sounds outside the gameworld which may very much be part of the experience of play: the acoustic soundscape of group play, the arcade environment or online conferencing [in multiplayer games]." Grimshaw as well addresses the same issue by

[10] Non-player character.

introducing the term *telediegesis* to denote the audio communication between players in multiplayer games.

Collins also finds diegesis “ill suited to games,” and explains that “the unique relationship in games posed by the fact that the audience is engaging directly in the sound playback process on screen [...] requires a new type of categorization of the sound-image relationship” (*Game Sound* 125). According to Collins, it is more accurate to separate sounds further into “the types of dynamic activity as they relate to diegesis and to the player;” thus, she utilizes attributes such as *linearity*, *interactivity* and *adaptivity*. A sound is called linear if the player is not in the capacity to affect it in anyway (except quitting the game, or skipping the sequence), such as cutscene audio or static background ambience. Interactivity refers to the type of activity where player input directly affects the sound: firing a gun, stepping on the gas or walking (footsteps). Adaptive sounds are subject to change by indirect player activity; the events that happen in the game (eventually driven by the player) affect how and which sounds are played: music changing into a victorious tone after player accomplishes a quest, or ambiance shifting from day to night as the game time progresses in *Elder Scrolls Online* (hereafter just ESO), or the heartbeat sound that plays when the player’s health drops under a certain amount in *Doom 3*. Linear, interactive and adaptive traits can be observed in both diegetic and nondiegetic sounds. Figure 8 shows the stages of player interactivity in dynamic game audio, including some examples in brackets.

	Nondynamic	**Dynamic**	
Nondiegetic	Linear [Static music]	Adaptive [Music responding to the zonal changes]	Interactive [Music affected by player input, menu buttons]
Diegetic	Linear [Static *source music*, static ambience]	Adaptive [Ambience responding to the weather changes]	Interactive [Footsteps, gunshots]

Figure 8. Player interactivity in dynamic game audio (Collins, *Game Sound* 125).

Both Jørgensen and Collin’s works show that the traditional notion of diegesis lacks sufficient depth in narratively categorizing game audio, and moreover, complicates the issue, due to the participatory and dynamic nature of games. On one hand, Collins (*Game Sound*) elaborates the dynamic activity in game audio; and on the other hand, Jørgensen’s spatial integration addresses the dynamic interfaces that game audio poses, possibly encouraging the incorporation of audio in user interface design. I agree that these models bring alternative perspectives to the discussion and provide solutions on a critical level; however, I argue that it may be beneficial to develop a simpler but efficient, design oriented approach, based on and extracted from the existing line of thought, to be utilized in sound design process as a straightforward alternative.

2.1.1. Dynamic Integration

Dynamic integration refers to the model I propose as an alternative approach to the topic of diegesis and sonic interfaces in game audio. This is an introductory concept to a larger model (*SISA*) that I will present at the end of this chapter. In the dynamic integration model, audio is examined in two dimensions, *narrative integration* and *dynamic activity*, as the first two elements of the multimodal ecology of game soundscape.

The notion of diegesis is adapted as *narrative integration* by omitting the problematic diegetic-nondiegetic separation and accommodating an approach similar to Jørgensen's spatial integration[11], where the sound is treated as a type of interface. In one end of the spectrum is *internal sound*, on the other is *external*. The separation is derived from the degree of integration which is defined by how internalized or externalized the sounds are to the game's narrative sphere. The most clear example of external sound is linear game music which is entirely detached from the interactive environment. The background music in *Screamer 2*, which can be manually replaced with any audio CD, is external. A clearly internal sound example, on the other hand, is the speech or footsteps of the player character's avatar. The grunts of the protagonist in *Doom II: Hell on Earth* are internal.

At first glance, the internal and external separation may seem just as a variant naming for diegetic and nondiegetic. However, the dimension of integration does not present a binary division unlike diegesis. The varying levels of integration between the extremities of the spectrum are counted as *integrated sounds*, in correspondence with Jørgensen's spatial integration. In this sense, the narrative integration domain takes into account that sounds may act as interfaces. Thus, the functionality of a sound may affect how internal or external it is. To

[11] Jørgensen uses the term *spatial* to denote the varying degrees of sound integration. I prefer to avoid using this term in this context, since it is conflicting with the widely used meaning of the word in audio production, which is the spatial positioning of sound in the audiovisual stage.

illustrate, the sound of a player character receiving a healing spell in *ESO* is less internal in comparison to the footsteps of the player, due the informational value that the healing spell carries. At the same time, the spell is more internal compared to the background music, because the spell happens *within* the gameworld. To clarify, it is not definite that if we hear the metaphorically positive chime when the spell is cast because it was internally originated from the caster, or just because the game system is conveying an external information that is 'healing received' to the player. On the other hand, the healing spell is still directly connected to an event that takes place in the gameworld, so it belongs to somewhere in between the integrational spectrum, unlike the straightforwardly internal footsteps or external music. It is partly *integrated* as an interface. In this sense, the integrational dimension provides a lower resolution but simpler and straightforward format compared to Jørgensen's spatial integration model, which defines five points of integration. I believe that the concept of narrative integration may provide an efficient design perspective for narratively thematizing sound effects and sonically functionalizing user interfaces.

Dynamic activity→ *Narrative Integration ↓*	**Static**	**Adaptive**	**Interactive**
External	- Static music (linear loops).	- Adaptive music (that is affected by the changes in the setting).	- Interactive music (that is triggered by player input) - External narration (narrator voice) - Overlay UI (menus)
Integrated		- Internal avatar sounds (narrated character thoughts, heartbeat)	- Integrated UI (using *boosting* items like potions, collecting bonus items like mushrooms and chocolate bars, purchasing items at kiosks)
Internal	- Static ambience (linear loops) - Static source music.	- Adaptive ambience (temporal changes in the environment) - Narrated NPC comments - Aired sound (radio announcements).	- Reactive environment - Dialogue - SFX (weapons, footsteps, gas pedal) - External avatar sounds (grunts) - Aired sound (changing the radio channel)

Figure 9. Dynamic integration of game audio including some examples.

The second dimension of the dynamic integration model comprises three stages of *dynamic activity*, inspired by Collin's work (*Game Audio* 125): *Static*, *adaptive* and *interactive*. The former implies that the player has no effect on how the sound behaves, and the sound remains static, i.e. non-changed, during the given sequence of the game (music in *Screamer 2*). The latter refers to the sounds that are directly affected by player input (footsteps in *Shadowrun*). Finally, adaptive sounds are subject to change via indirect player input, such as events that occur during the gameplay as a result of player activity (heartbeat sound in *Doom 3*). Understanding the varying levels of dynamic activity in game audio may provide insights on integrating game and audio events in interesting ways and designing diverse and dynamic sonic behaviours. Figure 9 combines the narrative integration and dynamic activity dimensions, and illustrates the dynamic integration model with generic examples.

2.2. CLARITY AND SIGNIFICANCE

In the section above, I interpreted the game audio as a dynamic narrative interface. Now, I will explore the type and amount of information, or meaning, that can be conveyed through sound. It was previously mentioned that Wilhelmsson and Wallén introduced the layers of cognitive, spectral, and dynamic load to allow observing and limiting excessive sonic congestion in the soundtrack. Their *combined model* aims to achieve this by assigning each sound a discrete value in three spectra: *cognitive significance*, *dominant frequency* band, and *average loudness*. This way, possible congestions can be observed and resolved, an adequate sonic intensity and informational clarity can be achieved.

The cognitive significance in question is a notion borrowed from Walter Murch (“Dense”). On a very basic level, Murch divides sounds depending on the information and emotion they carry, or *significance*, as I call it, and how humans cognitively perceive them. He argues that the audience is only capable of discerning a limited amount of information at a time, hence the balance between clarity and density should be systematically attained. Using the visible spectrum as a metaphor for *coldness* and *warmth* in meaning, he defines that the coldest sounds are *encoded* sounds, which carry the most direct information. Figure 10 shows an example of Murch’s conceptual model. “The clearest example of encoded sound is speech,” states Murch (“Dense”). On the contrary, the warmest sound is called *embodied* sound, the clearest example of it being music. The embodied sound can carry powerful emotional meaning, but the language it uses is abstract compared the concrete expression of speech. In the middle of the spectrum lies the mixture of encoded and embodied sounds: sound effects. Sounds can carry a direct message, like speech; but in the meantime, they can also manifest universal narratives and expressions, just like music. However, each of these simple elements (music, speech and sounds) can actually have complicated meanings, shifting towards colder or warmer ends of the spectrum:

> "And sound effects can mercurially slip away from their home base of yellow towards either edge, tinting themselves warmer and more 'musical,' or cooler and more 'linguistic' in the process. Sometimes a sound effect can be almost pure music. It doesn't declare itself openly as music because it is not melodic, but it can have a musical effect on you anyway: think of the dense ("orange") background sounds in Eraserhead. And sometimes a sound effect can deliver discrete packets of meaning that are almost like words. A door-knock, for instance, might be a "blue" microlanguage that says: "Someone's here!" And certain kinds of footsteps say simply: "Step! Step! Step!"" (Murch, "Dense").

Violet	Dialogue	**Encoded**
Green	Speech with embodied meaning, sounds with encoded meaning	**Warmer encoding**
Yellow	Sound effects	**Encoded/Embodied**
Orange	Sounds with embodied meaning, music with encoded meaning	**Colder embodiment**
Red	Music	**Embodied**

Figure 10. Murch's conceptual model ("Dense").

This approach is particularly relevant for linear film mixes, but it is important to note that most things happen in a nonlinear fashion in games. Thus, such delicate planning may be tricky to overcome in some mixing situations due to the transient dynamics of games. Nevertheless, understanding the significance of sounds may be highly useful during the design process in deciding, limiting or extending the amount and type of information or emotion that can be conveyed through sound.[12] On the side, mapping the cognitive meaning of each sound asset in the game engine may allow algorithmically monitoring the informational clarity of a game sound mix, as an idea that may be explored in further studies.

Alongside Murch's cognitive load, Wilhelmsson & Wallén cover frequency and loudness as secondary parameters.. Their combined model employ simple geometric forms to visualize these parameters of sound on paper. For example, a circle represents that the dominant frequency range for a given audio asset resides on the lower end of the audible spectrum; a

[12] Such design approach will be inspected in Chapter 3.1.

square represents the *mid* frequencies; and a triangle represents the high end. The size of the shape tells how loud the sound is on average. Even though I agree that the merits of such observation may reveal itself when analyzing a finished game soundtrack for critical reasons, I argue that this approach has limited usability in game audio production, since accurately estimating the spectral and dynamic characteristics of each asset prior to the creation would be impractical. In case that this model would be used to analyze the sound mix posterior to the asset creation, then I will further argue that the digital metering and analyzer plug-ins used in the game engine are far more efficient for this purpose; thus, the desired sonic intensity of a soundtrack should be achieved and monitored in the engine instead. In addition, I believe that the quantitative traits of sounds, such as spectral, dynamic and spatial parameters, are usually not directly connected to the functionalities of sound in games. They are rather the result of the design, not the cause. Therefore, they should be treated as the subjects of mixing, rather than as a part of a conceptual design methodology.

Consequently, based on Wilhelmsson & Wallén's interpretation of the IEZA framework (Huiberts and van Tol) and Murch's conceptual model ("Dense"), I realize that the informational clarity is a crucial element that should be taken into consideration in game sound design. Aiming at assessing a similar dimension in regards with the multimodal ecology of game sound, I propose my own interpretation of the concept, called *significance*. The element of s*ignificance* refers to the meaning and message carried by the sound, and it is partially inspired by Murch's encoded-embodied sounds ("Dense") and Back's micro-narratives. The significance of sound emanates from what it mimetically *depicts* or symbolically *suggests*. In other words, the dimension of significance treats sounds as either authentic or metaphorical elements.

2.2.1. Depictive Sounds

On one end, *depictive* sounds refer to the sounds that purposefully represent the authenticity of objects or events in the game. Most concrete and ambient sounds, such as the footsteps in *Shadowrun*, the shotgun fire in Doom 3, or the forest ambience in *Sword & Sworcery*, are depictive. Dialogue is straightforwardly depictive, and most internal objects and the environmental sounds are depictive too. Depictive sounds are mimetic; they replicate authentic events. Nonetheless, seeking authenticity through depiction is not always equal to capturing the sound that is most faithful to the reality; sounds may have to be molded into iconic forms that fit to the mental model the audience excepts. “Thus, thunder must crack, boom, or roll, and seagulls must utter high lonesome cries or harsh squawks; listeners will reject any of the myriad of other sounds made by thunder or seagulls as not authentic,” reasons Back. Some sounds may even need to be *caricaturized*, to actually make them believable, by “exaggerating the most salient features of the sound: [...] for example, if the sound of a door is not being clearly read as a door, designers will often retailor the sound to include details such as a latch click and doorknob release. These sounds may even be laid into the sound file at an exaggerated loudness in order to emphasize their effect” (Back).

To further elaborate the sense of authenticity and its effects in game sound design, Droumeva investigates two properties: fidelity and verisimilitude (134). The former represents how truthfully a sound is reproduced with regard to the source of the sound in game on a technological level. In other words, the level of quality based on the resolution of audio and the diversity of behaviour defines how faithful the sound is to the reality. The latter, verisimilitude, refers to the sense of authenticity that a game soundscape is able to present by creating a believable and interesting sonic space that varies over time. The intriguing fact here is that some games are able to achieve both fidelity and verisimilitude even though they prefer to use less realistic, outspokenly synthetic, even nostalgic audio elements. “In other words, *Super Mario*, *Zelda* or *Final Fantasy* just wouldn’t be recognizable to their audience, in our terms, possess verisimilitude, if it were not for their inter-textual references to iconic sounds of the past” (Droumeva 141). In this sense, truncated beeps and bleeps of *Fez* seem to have the same level of believability compared to the hyperrealistic war zones of *Battlefield 4*. Consequently, such sounds, *metaphoric sounds* as Walter Murch (“Stretching”) calls them, encourages designing sounds by considering not only *what* to depict but also *how* to depict.

2.2.2. Micro-Narratives

Providing answers to questions such as the ones above ultimately results in attempting to construct sonic *micro-narratives*. It needs to be decided if a rock only sounds like *a rock*, or it has a story to tell, even if that story is on a microscopic scale. Does the rock fall on the ground, or does somebody hit it with a pick? If it falls, what is the height of the fall? Is it a big rock or a piece of pebble? I may imagine that a group of rocks are first sliding, then falling on the ground.

In my imaginary miniature story, first I hear the debris sliding, then the low *thud* of the biggest piece of rock when it hits the earth, and finally, the story ends with more debris fading out as it is scattered on the ground. On the other hand, I may not need to express such a detailed narrative, and maybe all I need to have is the simple *thud* of a rock, without too much meaning to it. Finding the balance between the density and simplicity of meaning ultimately helps establishing the informational clarity of the overall soundscape.

Creating sonic micro-narratives can often resemble writing. Narrative sounds usually have the traditional beginning, middle and end type of story structure. “Because sound is inherently a time-based art, the designer has a much finer resolution in the grain of detail over time; matters such as the length of the echo or the sound of a coin dropping can be tailored to fit a particular set of circumstances,” explains Back. On the other hand, micro-narratives can also resemble painting. Designers carefully choose and manipulate properties such color, tone, sharpness and movement to paint a sonic picture that portray the concrete or abstract ideas in their mind.

Micro-narratives can also occur on longer sonic timelines. A clear example of how depictive sounds can communicate subtle yet impactful narratives is ambience: an atmosphere of secureness can be conveyed through the use of calm elements, such as a mild breeze and soft ocean waves. Likewise, howling wind and rasp caws of crows may suggest a harsh and threatening feeling. Such ambience track is made of several smaller scale stories. Ultimately, the entire mixture of micro-stories, small and big, form a cohesive soundscape that tells its macro-story.

2.2.3. Suggestive Sounds

At the opposite end of the spectrum of significance lies the *suggestive* sounds of abstract nature, purposefully designed to carry metaphorical meanings, in other words, to *suggest* a certain kind of emotion or outcome (e.g. suspense, victory) through an abstract language. Suggestive sounds are symbolic, and they usually involve musical elements; in fact, music is the clearest suggestive sound. As an example from the world of sound effects, levelling up in *ESO* results in a melodic, victorious motif which emotionally suggests a positive outcome and conveys a solid message that is ‘you leveled up.’ In this sense, suggestive sounds are generally suitable to act as an element of interface. Sounds that are able to communicate direct or subliminal messages through symbolic structures may procreate opportunities to integrate sounds in a functional way in which the game design profits. A common example of such integration is the *sonification* of game data through sound: in *Peggle 2*, the more *peggles* the player consecutively hits with a ball throw; the higher the pitch of the collision becomes, signifying that the score is increasing by each hit.

It is also possible to embed micro-stories in suggestive sounds. By manipulating the tonal qualities of a sound, metaphorical meanings can be expressed. The *envelope* of a sound refers to the various qualities of soundwave changing over time. Envelopes allow to shape the qualities such as pitch, amplitude, and length, just like using different brush types and strokes to paint elements with varying dynamics on a canvas. As a simple example, in *Dark Room*, I used a bubble sound, shaped with an upwards-moving pitch envelope to signify the sliding movement of some aqueous game characters. On the contrary, if the characters were blocked and could not move, the failed attempt of sliding would be suggested with a bubble sound that bends downwards.

"There are some sounds which are mimetic in their representation of realism (Doppler effects, recordings of real weapons, for example) and others that are more abstract in such representation (the caricature sound)," Grimshaw explains a similar distinction between depictive and suggestive sounds (230). However, most sounds are more complicated in reality and they carry both depictive and suggestive qualities. In *Dark Room*, the sliding sound mentioned above also included underlying authentic layers of water splashes, which gave them a depictive quality. Similarly, depictive sounds can be armed with suggestive tones simply by adding musical layers to the sound to convey metaphorical messages. Such hybrid sounds can be called *composite* sounds. On a second note, it is safe to generalize that in games which represent a more realistic world, the majority of sounds would be depictive, whereas games with more fantastic content would tend to use more suggestive elements. Then again, the opposite is sometimes true, as Grimshaw adds, "perhaps, in the more fantastic, imaginary worlds of non-realism FPS (first-person shooter) games, realist sound is required to anchor the gameworld in a simulacrum of reality such that the player may 'respond to it as if it were real'" (338).

To summarize, defining the significance of a sound can help enhance the sound design in several ways, including:

- ❏ Understanding in which type of sound effect (concrete, abstract or ambient) a certain sound asset falls. In general, concrete and ambient sounds are depictive, and abstract sounds are suggestive, but there are many exceptions.
- ❏ Creating sonic micro-narratives for individual sound effects.
- ❏ Establishing sense of authenticity in the sonic domain.
- ❏ Maintaining the informational clarity of the soundtrack under control by monitoring the meaning conveyed through each sound asset. By understanding which elements suggests or depicts what kind and amount of information, any possible cognitive *logjams* (Murch, "Dense") can be avoided, and a lucid soundscape can be achieved.
- ❏ Assigning functional meaning to sounds to employ them as a part of the user interface.

2.3. MULTISENSORY SYNCHRONIZATION

So far, I discussed sound design concepts mostly in the aural context. However, games are multisensory interfaces, meaning that they comprise visual and haptic elements on top of the ones that are aural. Especially when designing sonic narratives, it is crucial to approach sound with such multimodal perspective.

2.3.1. Visualization

The first thing to consider in the multisensory context is that whether or not the source of the sound is visualized on the screen. In film studies, Chion utilizes the term *acousmatic*, coined by R. Murray Schafer, to define the sounds that have no apparent source on the screen (*off-screen* sounds), and refers to the on-screen sounds as *visualized*. However, the division between on-screen and off-screen space signifies a dynamic context in many game genres, in which the player is in control of the camera perspective in real time. In *Doom 3*, the growls of an approaching zombie is only off-screen until the player turns her head towards it, but the footsteps of the avatar is absolutely off-screen since the feet of the avatar are never visible to the player. Thus, footsteps of the avatar are always acousmatic.

Acousmatic sounds can augment the narrative world of the game by extending the limits of what the screen can display. Likewise, temporarily off-screen sounds can give information about the surroundings and help the player to navigate in the gameworld. This is especially significant in the new generation Virtual Reality games in which the spatiality of sound is enhanced via the use of 3D audio. Additionally, "sound effects for health bars and GUI interfaces [sic] are unusual commissions for audio and can be considered as part of both the on-screen and the off-screen action" (Bridgett, *From the Shadows* 63). A creative use of off-screen sounds can be observed in *Amnesia: The Dark Descent*: Daniel, the protagonist, should avoid looking at the monster, otherwise he would go insane. Therefore, he must run away from it at all costs. As he cowers and waits for his doom to come in a dark corner, the growls and thrashing of the monster are the main cues which tell Daniel that the danger is either getting closer or moving away.

2.3.2. Synchronization

The visualization of sound eventually connects to how the image and sound are temporally linked. The time matching of image and sound can be referred to as *synchronization*. In films, the sound is either matched with the image (e.g. dialogue) or free from it (e.g. music). In the case of the former, a sound is *synchronous*, whereas in the case of the latter, a sound is *asynchronous*. However, there may be relatively synchronized elements as well. Chion considers environmental sounds semi-synchronized, since the ambience has the flexibility of loosely following what is happening on the screen. Even sometimes in Foley, in which the synchronization is usually of utmost importance, "approximate sync can seem just fine" (Ament 107).

Game audio differs from film in terms of synchronization as well. Collins describes synchronization in games by the term she coins, *kinesonic congruence*. "Interactive sound is event-driven," she emphasizes, and warns, "in games, however, there is the added modality of the player's events, meaning that sound may be congruent with the image or may be congruent with the action of the player. [… Therefore,] a mismatch may occur between the gesture of the player, the imagery of the game, and the sound" (*Playing* 31, 32). Collins also comments on game music in a similar line of thought: "Although scripted slow-motion shots [cutscenes] do exist, image and music cannot synchronize as closely in games as they can in film, because of the unpredictable temporal aspects of games" (*Game Sound* 128).

In addition to the involvement of player activity, I previously introduced the concept of *relative synchronization* to clarify how foley sounds work differently in game audio, in terms of how the sound and image are connected.[13] To recapitulate, the sound does not always precisely match the image in games, just like the generic footsteps that are used in most turn-based tactical games for multiple units with different movement animations (e.g. *Shadow Run*). However, it is fair to say that, in general, depictive visualized sounds require a greater degree of audiovisual synchronization, even when the matching is based not on image but action. For instance, in *Dark Room*, the sliding sounds of the characters are tied to the tapping action, but I also took care that the sounds relatively match to the speed and articulation of the sliding animation.

Another point is that the synchronization of sound, image and action is not only a practically necessary operation in game audio design, but also a narratively functional one. The phenomenon of synchresis is defined as "the forging between something one sees and something one hears [, …] the mental fusion between a sound and a visual when these occur at exactly the same time" ("Synchresis"). What synchresis can afford to game sound is that the reassociation of meaning through synchronized occurrence of sound, image and action. To exemplify, Grimshaw quotes, "decades of tin-sheet thunder and coconut shell hooves prove […] that fidelity to source is not a property of film sound, but an effect of synchronization" (231). Thus, convincing use of synchronization can effectively increase the sense of authenticity in sound, or the way Grimshaw urges, is "[…] more important than providing and using an authentic sound" (232).

I conclude that the connection between image and sound is extremely relevant in game sound, since the majority of the sounds in games either have a visible source or an interactive event to which they are connected in the game. Moreover, some game platforms incorporate haptic feedback through controllers, which is synchronized with the audiovisual action up to varying degrees. Many *PlayStation 4* games provide vibrating pulses via a proprietary gamepad, and Rovio "expanded the gaming experience in *Angry Birds Friends* to include tactile effects

[13] See Chapter 1.5.

created with *TouchSense® Engage*, Immersion's haptic technology." Accordingly, the concepts of relative synchronization and kinesonic congruence make it critical to design in advance whether the sound will be synced to the image, to the action, to the other possible modalities, or to none. Moreover, synchronization is also relevant in terms of understanding the dependencies between different departments in game development (e.g. animation and sound). [14] Thus, it becomes imperative to employ synchronization as an additional dimension for designing the multimodal ecology of game sound.

I suggest that the dimension of synchronization, as the final element of the multimodal ecology of game soundscape, should be based on three stages of congruence: *Absolute*, *relative*, and *independent*. In *absolute synchronization*, the sound is precisely tied to the image. The clearest example of such syncing can be observed in cutscenes, but most in-game sound effects can be considered in this group as well, such as firing a gun of the player or the animated movements of NPC's in a first-person shooter game. The *relative synchronization* refers to the syncing that is based on the action, rather than the image. For instance, in *Tomb Raider*, when Lara Croft loots the dead bodies of the enemies, the generic sound of reaching and picking up an item is synced to the avatar's action, and only relatively matched with the animation. In the case that absolute and relative synchronization mutually exist in a given sound event, then it shall be considered as absolute synchronization for the sake of simplicity. Finally, *independent sounds* are free from any type of visual congruence since they are either not visually represented in the game, or only loosely connected to the image. Some examples of the *independent* sounds include music, narration, user interface responses that do not have a visual counterpart, and the ambient soundscape that is vaguely synced the visual environment.

[14] See Chapter 1.4 for more information about production dependencies.

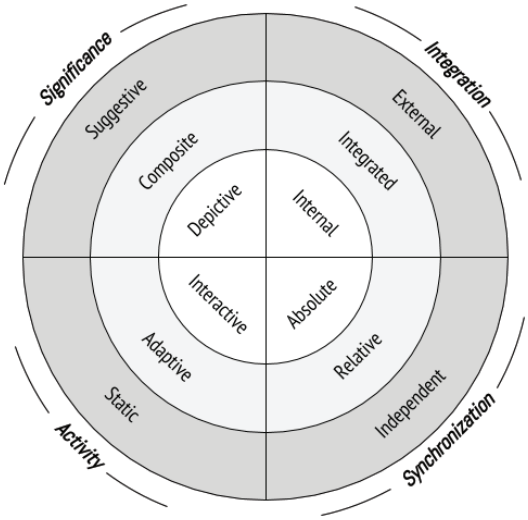

Figure 11. The SISA model.

2.4. THE SISA MODEL

In this chapter, I discussed that by being conscious of certain attributes of sound, the designer can better establish sonic functionality and thematization, multimodal integrity, diverse narratives, clarity and meaning. Now I will suggest a diagrammatic model called SISA, which uses the various taxonomies and models I previously presented and allows methodologically incorporating the concepts in question to the sound design process. As an acronym, SISA stands for significance, integration, synchronization, and activity, four dimension that ultimately form the multimodal ecology of game sound. Each four dimensions of SISA consists of three attributes, as shown in Figure 11. The outer line of the diagram represents more abstract, external and linear elements of the soundscape. The further one goes towards the center, the elements become closely integrated to the narrative sphere, ultimately becoming internal and entirely dynamic parts of the gameworld at the core layer. Figure 12 summarizes the terminology used in the model and includes some generic examples for each attribute.

In conclusion, by utilizing the elements of significance, integration, synchronization, and activity, the SISA model establishes a conceptual and functional foundation for sound design. By determining where each sound belongs on the diagram, the attributes that form the multimodal ecology of the game soundscape can be understood to guide the design process.

Ultimately, the SISA model aims to provide a pragmatic approach to the ongoing game audio frameworking discussions from the sound designer's perspective, focusing on the functionalities and intercontextual traits of sounds. It is also worth mentioning that the SISA model is essentially optimized for sound effect design; however, this does not mean that it omits music and speech. Finally, this model requires to be methodically applied and tested in practice in order to genuinely assess its functional potential, its merits and downsides.

Significance	The meaning and authenticity of the sound.	**Example**
Depictive	Sounds that represent the authenticity of concrete objects or events.	Gun shot
Composite	Sounds that have both depictive and suggestive features.	Using a super attack
Suggestive	Sounds that represent metaphorical meanings in an abstract form.	Achievement unlocked
Integration	Defines in what degree a sound is narratively integrated into the gameworld.	**Example**
External	Sounds that reside outside of the fictional gameworld.	Combat music
Integrated	External sounds that are narratively integrated into the fictional gameworld.	Drinking a potion
Internal	Sounds that originate from and reside within the fictional gameworld.	Player dialogue
Synchronization	The temporal connection between sound, image and actions.	**Example**
Independent	Sounds that have no direct temporal connection with the image or the action.	Narration
Relative	Sounds that are temporally synced to the action.	Footsteps
Absolute	Sounds that are temporally synced to the image.	Cutscene audio
Activity	The dynamic interactions between sound, player actions and game events.	**Example**
Static	Linear sounds that does not allow interactivity.	Linear ambiance
Adaptive	Sounds that are triggered or affected by the changes in the game setting.	Heartbeat of the avatar
Interactive	Sounds that are triggered or affected by direct player action.	Opening a door

Figure 12. The SISA model: dimensions and attributes summarized, including examples.

3. SOUNDTRACK: The Playback of an Acoustic Ecology

In the previous chapter, I presented a framework on which I built a practical model for designing the multimodal ecology of the game soundscape. In this final chapter, I will move away from investigating the individual elements that create the game soundscape, and shift my focus to observe game sound from a wider perspective that is the acoustic ecology of games. To recapitulate, the acoustic ecology of games is defined as the sonic relationship between the game soundscape and the player actions, and the way of understanding game sound in such a systemic way is heavily inspired by Mark Grimshaw's seminal thesis, *The Acoustic Ecology of the First-Person Shooter*. This chapter aims to contribute to the line of thought sprouted from Grimshaw's work, by concentrating on the implementation related methods for designing such a sonic system.

"Players participate in the construction and maintenance of the acoustic ecology by triggering sounds and the soundscape affords information in the form of sound for players to engage with and to potentially respond to," Grimshaw summarizes (328). In another seminal work that deals with the sonic interactivity in games, *Playing with Sound*, Collins argues that "the experience of interacting *with* sound is fundamentally different in terms of listener/player's experience from that of listening *to* (noninteractive) sound" (7). In this sense, the acoustic ecology of game sound is derived from a ludological point of view, rather than a narratological one. What this suggests is that designing the acoustic ecology of a game means designing not for the sound's sake but the player experience. In other words, a game sound is not complete without player interaction, hence it must be tailored to fit to the nonlinear and participative dynamics of the game. A relevant question this chapter poses is that how can the most predictable aural scenario be outlined during the design process to address the unpredictabilities that may or will occur during the game play.

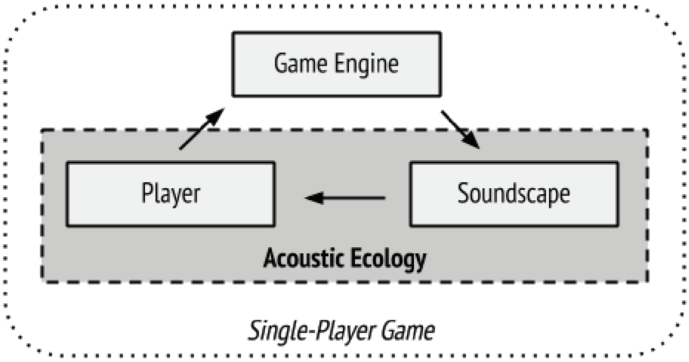

Figure 13. *The Acoustic Ecology of the First-Person Shooter* in its most basic form (Grimshaw).

Before delving into the individual methods and approaches to address the question posed above, the Figure 14 illustrates how the most basic form of Grimshaw's acoustic ecology can be connected to the framework presented in the previous chapter. Grimshaw's full model is much more comprehensive, but, since it is optimized for the FPS game genre, I found that the most basic structure of the model is generic enough to apply to any games, and sufficient enough for the purpose of this chapter. As can be seen from the diagram, the multimodal ecology of the game soundscape can be understood as a part of the game's acoustic ecology, which is communicated through the SISA model between the player and the engine. Then, I employ the term *soundtrack* to signify the audio output of the game sound, the final content that reaches to the player's ears, which is essentially the physical representation of the digital acoustic ecology of the game. I believe that the subtle distinction between an acoustic ecology and a soundtrack is practically necessary since the soundtrack is in fact the product of the final manipulation and optimization process of the game's acoustic ecology. In other words, a game soundtrack is the dynamically mixed and optimized output of the game's acoustic ecology, specifically tailored to provide the best possible auditory experience for the player. Consequently, the ways to how to tailor such a soundtrack is the main concern of this chapter.

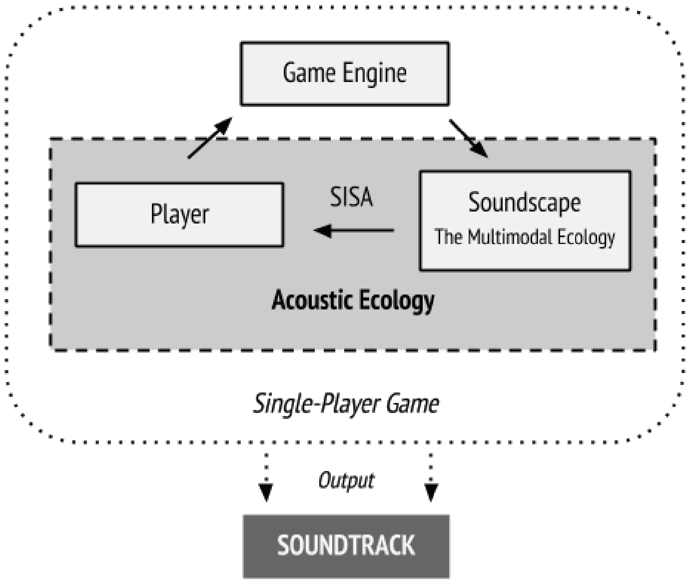

Figure 14. An interpretation of *The Acoustic Ecology of the First-Person Shooter* (Grimshaw).

3.1. LISTENING TO THE SOUNDTRACK

The way a soundtrack is shaped essentially depends on how the soundtrack is listened to. Many scholars attempted to outline the various modes that the audience and/or the players perceptually utilize during listening, including Chion, Truax, Grimshaw and Droumeva. These listening modes vary greatly in an effort to cover the diverse aspects of listening in different contexts, and my belief is that a relevant completion of the existing categories can lead to forging a condensed rephrasal of the existing taxonomy which can provide a fruitful design scheme for game sound. Figure 15 summarizes some notable examples of listening modes that are most relevant for the player experience.

Most of the listening modes are not "mutually exclusive" (Collins, *Playing* 5), and the attentional focus of the player continuously shifts between different modes. In fact, observing the modes outlined in Figure 13, *attention* reveals itself as the keyword. To what element of the experience the player directs her attention defines which listening mode is employed in a given period of playing. Therefore, it becomes imperative to predict scenarios that would help guiding player's attention to the most relevant sonic details during the gameplay. I suggest that this design challenge can be solved by employing a concept I shall term *attentional mixing*.

Listening Mode	*Description*	*Example*
Casual listening (Chion)	Attention to the cause or source of the sound.	Positioning and identifying objects in the space.
Semantic listening (Chion)	Attention to the message or meaning of the sound.	Decoding what an NPC's speech or an UI alert conveys.
Reduced listening (Chion)	Attention to the acoustic qualities of the sound.	Analyzing the frequency range or reverb tail of a sound.
Background listening (Truax)	Non-attentional listening by reducing sounds to a decorative background element.	Backgrounding the music and ambience sounds.
Listening-in-readiness (Truax)	Listening with an expectation of hearing a specific sound and taking a certain action accordingly.	Responding to UI alerts, approaching enemy growls or emerging combat music.
Retentive listening (Huron)	Listening while trying to memorize certain qualities of sound.	Repeating a sequence of tones.
Navigational listening (Grimshaw)	Attention to the spatial position and resonant qualities of the sound.	Identifying where the enemy hides, aurally locating a certain spot on the map.
Interactive listening (Collins, *Playing*)[15]	Creating sounds by interactive and responsive player participation.	Creating sonic or musical elements in response to the game..
Imaginative listening (Droumeva)	A listening mode that supplies the perceptual conditions for immersion.	Getting immersed by the sonic imagery that the game soundtrack provides.

Figure 15. Some notable listening modes.

In attentional mixing, the mixing decisions are prioritized depending on where the player's attention should be focused on. Before going into details, I strongly believe that the traditional sound mixing is an absolutely crucial implementation element, if not the most important, for achieving a clear, intelligible and enjoyable soundtrack. However, the topic of this thesis is exclusive of such hands-on techniques for game sound. Alternatively, I aim to present a conceptual and complementary framework that is possibly helpful in tailoring a coherent and clear game soundtrack. As a basis, Figure 16 rephrases the aforementioned listening modes and provides a compact scheme to be utilized in game sound design.

[15] Interactive listening is a term I devise to cover the numerous ways in which the player interacts with game sound that Collins suggests (*Playing*).

Listening Mode	*Description*	*Main Related Mode*	*Example*
Descriptive listening	Identifying the source of the sound.	Casual, navigational and reduced listening.	Locating characters, identifying events and the surroundings.
Informative listening	Identifying the message of the sound.	Semantic and reduced listening, listening-in-readiness.	Decoding the meaning of speech or alert tones.
Evocative listening	Getting immersed and entertained in the soundscape.	Imaginative and casual listening.	Feeling terrified by the ambient drone, feeling heroic by the avatar's war cry.
Participative listening	Reacting to the sonic events and triggering sounds by participating in the soundscape.	Interactive, retentive and reduced listening, listening-in-readiness.	Taking action or evoking/manipulating sounds by direct player input in response to what is heard.
Communal listening	Listening to the sounds that the other players and the game audience make.	Semantic, interactive and background listening.	Listening to the multiplayer chat, or the exclamation of the audience in the room during a sports game.

Figure 16. A reinterpretation of the common listening modes.

3.1.1. Functions of Sound

By understanding what kind of elements into which the player's attention is divided, alternating mix states can be established, or the cognitive clarity[16] of the mix can be attained. Therefore, the listening modes presented in Figure 14 can provide a starting point for attentional mixing. Different modes of listening hint various functions of sound in games: describing the surroundings; informing about the meaning of the events; evoking various moods; affording participation with the gameworld; and communicating with others outside of the game, about the game. The brief fictional game play scenario below demonstrates how the various functions of sound can be communicated through different listening modes:

> As I open a door, the creaky sound emphasizes that it is an old wooden door (description of the source), and at the same time, the slow and careful articulation of the sound hints that my character is acting in a sneaky and cautious way (information about the sound event). A voice is heard from the left of the room (description of the position), saying, "Who is there?" (information). The clear sign which implies that I was noticed by the enemy forces me to draw

[16] See Chapter 2.2 for more details on the clarity of sound.

> my weapon (reactive participation), and the music adapts to the situation by changing into a thrilling passage (evocation). I call my teammates for help through the microphone (social communication) before things get nasty.

A couple of notable details can be observed in the example above. First, the same sound can allow more than one function (the door sound or the enemy's speech). Second, there are several sounds that can be simultaneously attended to. Resultingly, understanding the focus of player's attention can be insightful; however, identifying to what the player is listening is not sufficient enough or too abstract a reference by itself to base a sound mix on. As a solution, the elements of the game's acoustic ecology can be divided into mixing subgroups that can be dynamically foregrounded or backgrounded depending on what the main focus is at a given time.

3.1.2. Attentional Layers

In fact, a common element that has been mentioned both in film (Weis and Belton 357, Chion) and game studies (Huiberts and van Tol, Droumeva) is a three-stage attentional positioning, probably first suggested by Walter Murch. "Sound is divided into foreground, midground and background, each describing a different level of attention intended by the designer," explains Huiberts and van Tol. "Foreground is meant to be listened to, while midground and background are more or less to be simply heard. Mid-ground provides a context to foreground and has a direct bearing on the subject in hand, while background sets the scene of it all." The valuable information distilled from the listening modes and the functions of sound posed by these modes can provide grounds for establishing such attentional layering of the soundtrack. "Since each of those layers is separate, you can still control them, and you can emphasize certain elements, and de-emphasize others the way an orchestrator might emphasize the strings versus the trombones, or tympani versus the woodwinds," Murch explains how such layers can be manipulated.

But how can one attain such planned grouping in the dynamic environments of games? To begin with, the amount of detail that needs to be applied in a game mix is heavily dependant on the nature of the game. The mechanics and the narrative of the game defines the possible game states in which the player can find herself. For instance, the game can shift from calm moments to action sequences, or from puzzle solving to car chasing. Once these states are outlined, they can be treated as individual sequences that have their own custom-tailored attentional layers. In *Old Gods*, the player constantly shifts between exploration, combat and spellcasting modes. Each of these modes are in fact different states that require individual sonic attention. Figure 17 illustrates some gameplay scenarios from *Old Gods* for each game state, and demonstrates how these states can be assigned to specific attentional layers.

By incorporating an adaptive system that understands in which condition the player is in a given game sequence, and then altering the mix accordingly, the soundtrack can be dynamically manipulated (Bridgett, “Adaptive Audio”). In fact, *state-based*, *event-based* or *snapshot mixing* is an established technique that is frequently used in game sound. “Using these [state-based] systems, a particular sound, or group of sounds, can be made deliberately louder or quieter at a particular moment, and this allows sound designers the ability to make artistic decisions about sound […],” explains Bridgett (*From the Shadows* 197). Not only volume of the sound, but all kinds of parameters such as frequency spectrum, depth, spatial positioning and dynamics, can be affected through such arrangements. I see state-based mixing and similar techniques as not equal to attentional mixing but rather as a tool to achieve it. For instance, the sonic arrangements (e.g. manipulations to the spectral and dynamic qualities) can already be embedded into the sound assets themselves, or there may be just a single mix state to be adjusted, but aesthetic considerations posed by the attentional positioning (i.e. foreground, midground and background) and listening modes can still be used to guide the design process of the soundtrack. In other words, I suggest that the attentional mixing can be understood as a conceptual framework that can be used as a basis for establishing a mixing agenda, rather than being a practical design method by itself.

Exploration	Audio Type	Description	Listening Mode
Foreground	Environment Narration	Emphasizing the evocativeness and immersion through ambience and narration.	Evocative Informative
Midground	Characters Objects Music	The sounds of the avatar (e.g. footsteps, breathing), interactable objects (e.g. doors, chests), and the music descriptively and evocatively support the foreground.	Descriptive Evocative
Background	Feedback	No urgent events happen in this state. Any UI sound is backgrounded.	Informative
Combat	**Audio Type**	**Description**	**Listening Mode**
Foreground	Character Feedback	Character actions (e.g. attacks, vocals) and integrated feedback sounds (e.g. damage taken, hit, or miss) are emphasized.	Descriptive Informative
Midground	Music Objects	Music and objects in the surrounding increase evocativeness.	Descriptive Evocative
Background	Environment	Ambience is de-emphasized in order to reduce sonic clutter.	Descriptive
Spellcasting	**Audio Type**	**Description**	**Listening Mode**
Foreground	Character Feedback	Internal avatar sounds (e.g. breathing, ear ringing) and spellcasting fail or success sounds are emphasized.	Descriptive Informative
Midground	Narration Objects	Narration may occasionally give some hints and the magical totems within the surroundings emanate looping sonic presence.	Evocative Informative
Background	Music Environment	Music and ambience is backgrounded in order to make space for the feedback sounds.	Descriptive Evocative

Figure 17. Game states and related sonic prioritization schemes in *Old Gods.*

CONCLUSION

She suddenly opened her eyes to a misty, dark forest. From the high rocky spot she stood, she could hear the gentle breeze through the birch trees covering the land like a thick carpet, and the steady sound of the rain falling softly on the forest ground. She started to walk down through the stone path into the darkness looming ahead, as her determined footsteps faded into a muffled pattering underneath the drizzling rain. Not after a long while, as the moon started to elude her vision behind the tall trees, she reached to the lantern hanging from her side and pulled it in front her with a rasp squeak, tearing through the tranquil fabric of the forest. Right at that instance, an irritated caw of a crow echoing at a threateningly close distance made her flinch. As she turned to look, the darkness covering that very spot within the trees felt so utterly black that it was almost palpable. And the gloom was spreading, struggling to reach her and steal the frail remnants of moonlight from her. Then, suddenly, she began to hear the faint whispers, surrounding her from all directions. She turned around to see who was out there, but there was no one to be seen. Then the whispers began to blur, shifting into menacing tones, like unintelligible, ill willed incantations. As she began to notice the increasing ringing in her ears, she quickly reached for the crude matchsticks in her pocket and gave life to the lantern with a trembling hand. The gloomy entity was fighting against the frail light emanating from the lantern, and the ringing in her ears raised to a deafening scream as the twisted whispers engulfed her like a murky layer of fog. Accepting the corporeality of the menace surrounding her, she closed her eyes, and started to breath. Focusing only on the air coming in and out of her lungs, she began to feel the ominous sounds slowly retreating, and then reluctantly fading away as they loosen their grip off her mind. After one last long breath, she opened her eyes. The darkness was gone. Slowly, the rain and the wind began to fill the soundscape of her perception with their soothing hiss. Victoria turned away from that wretched spot, threw a curse at the damnable crow and kept moving forward into the forest to find what she was looking for in this accursed forest.

The passage above is an attempt to illustrate the immersive player experience in *Old Gods*, from the perspective of Victoria, the protagonist. Inspired by the vigorous design process in which I tried to surround Victoria with an impactful sonic reality, the hypothesis of this thesis was instinctively revealed to me: sound plays a substantial role in communicating the game's narrative to the player, augmenting the experience by expanding on what the screen is able to display. Moreover, sound conveys valuable information regarding the game play by acting as a ludological interface, hence playing a crucial role in the design of the game. If getting my hands dirty with recording and implementing sounds for several games, including *Old Gods*, is not enough of an effort to prove to myself the substantiality of sound in games, then years of gaming experience in almost all genres was enough to remind me that the most memorable games are the ones which have a memorable soundtrack.

In a quest to question and scrutinize this belief of mine in game sound, I attempted to analyze the individual components of game sound, and how they make a coherent soundtrack as a whole. I explored the sound's relationship with other game elements and modalities, and tried to determine in what kind of fashion such coherent and powerful sound can be produced as a part of the game development.

I set out by introducing the key definitions in game audio during the first chapter, and defining the scope of the thesis. I dissected the game sound production into iterative stages and tasks, and introduced a new taxonomy to describe each of these components, which as a whole outlined a practical workflow. Additionally, I introduced the concept of *sound design mindsets* to achieve a holistic understanding of game sound design workflow. Finally, I reinterpreted sound effect categories based on the production methods with a game-specific approach, which resulted in an alternative taxonomy. The attempts to outline a production workflow using a fresh terminology in this chapter strongly supported my belief that the ideal game sound design should be based on iterative, collaborative and cross-disciplinary process, with a socially engaging, proactive and synergic attitude.

Chapter 2: *Soundscape* constituted the main framework for the topic of the thesis. Here, I investigated the seminal theories and concepts that are immediately relevant to game sound design. The main subjects of discussion were the diegetic correspondence of sound, the functions of sound as an interface, the participative traits of sound, the meaning and narrative traits of sound, and the multimodal integrity of sound. For each subject, I followed a methodology in which I first summarize and analyze the existing literature, and then present my own interpretation in form of a new model that can be applied in practice. Several new taxonomies were introduced, finally forming a bigger design concept, called the SISA model. Overall, the chapter was an attempt to outline an in depth framework for game sound design, and suggest ways to employ the outlined ideas by utilizing conceptual models. The topic was thematized as *the multimodal ecology* of game sound in an attempt to consolidate the subjects introduced in the chapter as a cohesive concept, which can then be connected to the last chapter, *Soundtrack*.

The final chapter, *Soundtrack*, was an attempt to take the concept of multimodal ecology one step further and incorporate it with the concept of *acoustic ecology*, inspired by the writers such as Murray Schafer, Truax and Grimshaw. In this sense, the multimodal ecology of game soundscape was considered as an element which partially creates the acoustic ecology, and the acoustic ecology as a part of the whole soundtrack. From there, some concepts including listening modes, functionalities of sound and attentional mixing were explored, in order to provide fruitful ideas for the refining process of the soundtrack. An important perspective that the chapter took was prioritizing the player participation in game play, hence questioning how taking the player experience into consideration can affect the sound design in a beneficial way.

Overall, the thesis aimed to contribute to the game sound design practice by suggesting conceptual methods, based on the provided framework. To stress it once more, most of the methods in question are conceptual, hence the title of the thesis. Practical techniques such as recording, mixing and integration practices were excluded to maintain the focus on conceptual approaches. Resultingly, the methods and models introduced throughout the thesis need to be tested in practice. An analysis of how these methods perform when thoroughly applied to an actual game production may be a possible future expansion for this study. Another interesting extension may be exploring the idea of creating an algorithm which would visualize the cognitive density of the soundscape, a topic discussed in Chapter 2.2. If the depictive and suggestive values of each sound asset are quantified in advance, these values could be used to observe the significance of the soundscape on a per-frame basis, to allow real-time cognitive metering, hence affording a whole new dimension in sound mixing.

The focus of the thesis was mainly maintained on the design and production process of sound effects, although music and speech were not entirely excluded since all these subcategories of audio are strongly interconnected. Another point to note is that the majority of the thesis was intuitively based on the conventions of single-player games. This was due to the ever-increasing, immense range of variety in game genres, rather than a deliberate choice. Most methods and analyses presented throughout the thesis essentially aimed to be suited for any type of games regardless of the genre; however, I agree that this generic approach might have resulted in some of the concepts not being adequate for every genre, especially concerning the multi-player games due to their unique participative characteristics.

To conclude, my greatest hope is that this study can provide a guideline to help better understand the complexities and challenges of the elusive beast that is game audio, to tame it, and to exploit it to realize its full potential in game design. At least, to my satisfaction, I feel that this endeavour took me much closer to having a secure grip on the leash of that beast. Then again, most of the time, sound design is not about controlling but experimenting. In other words, “to be a sound designer is to fail,” as Seminario from Blizzard Entertainment puts it, “and to fail often. An expert is –hold on, there's a quote that I just read the other day– an expert is one who's made all of the mistakes already. I think that's right. Give or take a few words" (Farokhmanesh). That being so, I hope that this text will help the reader to reach the point of doing *all of the mistakes* in game sound much quicker.

APPENDIX: Key Terms

- **Audio asset**

  An individual piece of designed audio file which can either be a sound effect, music track or speech clip.

- **Asset creation**

  Production and design process of creating audio assets.

- **Cutscene (Cinematics):**

  Linear video sequences that occur in between gameplay.

- **Directing**

  Conducting the entire audio design process.

- **Gameworld**

  The environment within the game in which the act of playing occurs.

- **Implementation (Integration)**

  The process of integrating finished assets into the game engine and refining the soundtrack.

- **Iterative**

  The cycle of applying changes according to the result of the previous application.

- **NPC**

  Non-player character.

- **Sound effect**

  An individual, designed piece of sound.

- **Sound event**

  A game event that triggers a singular or a set of audio actions.

- **Sound object (Sound emitter)**

  A game object that parents an audio asset (or more) and than can emits sound.

- **Soundscape**

  The entire sonic environment of the gameworld, including all of the sound objects and events.

- **Sound track**

  Each individual layer of audio in a given asset.

- **Soundtrack**

  The entire audio output of the game.

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ABSTRACT

Existing game audio literature covers a plentitude of topics including practical areas such as production techniques, as well as theoretical areas such as terminology and taxonomy. However, these studies can still be considered somewhat limited in quantity and variety, since games are an academically young field, and game audio is even a smaller niche. In response to this scarcity, this study aims to provide a contribution to game audio studies, specifically aiming at exploring the sound effect design and production methods from the point of view of the sound designer. Most studies in similar vein either focus on directly hands on practices or solely theoretical aspects of game sound. Correspondingly, this thesis focuses on filling the gap between theory and practice by establishing a theoretical framework and numerous conceptual models that can be pragmatically applied in game sound design. The conclusions of the study are constructed and exemplified based on references to the existing literature and resources, numerous published video games, and various practical methods the author has applied in his own game projects. Ultimately, the thesis aims to provide a guideline that can help in creating a game soundtrack that is both narratively and ludologically cohesive, and that has contextual integrity regarding all the other game modalities.

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